Lasers in Surgery and Medicine 20:1–5 (1997)

Treatment of Leg Telangiectasia Using a Long-Pulse Dye Laser at 595 nm

James Hsia, PhD,[1]* Joseph A. Lowery, MS,[2] and Brian Zelickson, MD[2,3]

[1]Candela Corporation, Wayland, Massachusetts 01778
[2]Abbott Northwestern Hospital, Minneapolis, Minnesota 55407
[3]Skin Specialists Limited, Minneapolis, Minnesota 55402

Background and Objective: **Pulsed dye lasers (PDL) operating at 585 nm wavelength and 0.45 msec pulsewidth offer effective treatment for port wine stains (PWS). Vessels in leg telangiectasias are larger than those in PWS. Longer pulsewidths and wavelengths may improve clearance of these larger vessels.**
Study Design/Materials and Methods: **Twenty patients were treated using PDL at 595 nm and 1.5 msec. Vessel diameters ranging from 0.635 to 1.067 mm were treated using energy densities of 15 and 18 J/cm^2, and a 2 × 7 mm elliptical spot. Telangiectasia clearance and complications were scored at 6-weeks and 5-months following the single treatment.**
Results: **Results demonstrated >50% clearance by 6 weeks in 11/26 (42.3%) patients using 15 J/cm^2, and 6/13 (45.2%) using 18 J/cm^2. By 5 months >50% clearance was noted in 18/34 (53.0%) using 15 J/cm^2, and 11/17 (64.7%) using 18 J/cm^2. Complications were minor and infrequent.**
Conclusion: **The long-pulse PDL may have a role in treating leg telangiectasias. Lasers Surg Med 20:1–5, 1997.**

Key words: **cosmetic laser treatment; cutaneous laser surgery; dermatology lasers; laser surgery; leg veins; pulsed dye laser; selective photothermolysis; vascular lesions**

INTRODUCTION

The role of pulsed dye lasers (PDL) in the management of cutaneous vascular lesions such as port wine stains (PWS) and facial spider veins has been well established. However, attempts at using the PDL to treat leg telangiectasia have until now been notably unsuccessful except for the smallest vessels, those measuring 0.2 mm in diameter or smaller [1]. For example, Polla et al. [2] treated 35 leg telangiectasias with the Candela PDL using a 577 nm wavelength, 0.36-msec pulse duration, and 1-, 2-, and 3-mm-diameter spot sizes. Of the vessels treated, only 27% had greater than 50% clearing, and 73% showed little response to treatment. The lesions that did respond were the very small, raised, red/pink vessels.

The wavelength and pulse duration used above reflect those first identified for the treatment of PWS according to the principles of selective photothermolysis proposed by Anderson and Parrish [3]. The 577-nm wavelength was initially selected to match the yellow absorption peak of oxyhemoglobin, a prominent chromophore in the blood. A more optimal wavelength for PWS was later determined to be 585 nm by Tan et al. [4] who showed clinically that this longer wavelength produced injury to deeper vessels than did the 577-nm wavelength. Wavelengths longer than 585 nm should theoretically provide for even deeper penetration in the skin.

The theoretically ideal pulse duration was calculated by Van Gemert et al. [5] to be in the range of 1 to 10 msec based on thermal diffusion and tissue optics considerations for 0.08-mm-diameter PWS vessels. However, PDL technology at

*Correspondence to: James Hsia, Candela Corporation, 530 Boston Post Road, Wayland, MA 01778.

Accepted for publication 9 April 1996.

TABLE 1. Standard Hypodermic Needle Tubing Gauge and Respective Outside Diameter

Needle gauge	Outside diameter (mm)
19	1.067
20	0.889
21	0.813
22	0.711
23	0.635

the time was limited to a longest achievable pulse duration of 0.45 msec. Although this proved effective for the smaller vessels of PWS, it was generally recognized that longer pulse durations, if achievable, would be more efficacious for larger vessels.

The majority of leg telangiectasias are in the range of 0.1 to 1.0 mm in diameter, much larger than the 0.1-mm-diameter or smaller vessels of PWS. It is therefore reasonable to expect from theoretical considerations that the ideal laser parameters for the treatment of telangiectasias would be considerably different from those for PWS.

To this end the authors performed a clinical investigation to determine the effect of using a PDL with a longer pulse duration and a longer wavelength to treat telangiectasias of the leg.

MATERIALS AND METHODS

Twenty patients, 19 women and one man, were enrolled in the clinical study, which was carried out under the approval of the Institutional Human Studies Committee of Abbott Northwestern Hospitals. All patients had at least three sites exhibiting comparable telangiectasias of the leg with vessel diameters nominally ranging from 0.6 to 1.0 mm. The actual range for the vessel diameters was 0.635 mm to 1.067 mm as determined by direct comparison with a graded series of hypodermic needles, gauge 19 to 23 (PrecisionGlide®, Becton Dickinson & Co., Franklin Lakes, NJ). The needles were placed next to the length of vessel to be treated until the needle with a diameter most comparable to that of the vessel was determined visually. The gauge of the matching needle was then noted for each treatment area. The relationship between the hypodermic needle's gauge size and the corresponding outside diameter of the needles is shown in Table 1.

All patients were at least 18 years of age, provided signed informed consent, and did not exhibit any of the following conditions which would have precluded laser treatment of their telangiectasias: scarring, infection, or suntan in the area to be treated; pregnancy; anticoagulative or thromboembolic conditions; or use of dietary iron supplements. The study was also limited to patients with skin types of I, II, or III. However, one of the 20 patients treated was an African-American woman exhibiting a skin type of VI.

The laser used was a pulsed dye laser (Candela Laser Corporation, Wayland, MA) which was operated for the study at a wavelength of 595 nm, a pulse duration of 1.5 msec, and a maximum pulse repetition rate of one pulse every 3 sec (0.3 Hz). The laser energy was delivered to the treatment areas via a delivery system consisting of a quartz optical fiber coupled to a handpiece which transformed the light into an elliptical spot with major and minor axis dimensions of 7 mm and 2 mm, respectively.

Each of the 20 patients received laser treatments on three telangiectatic sites, two using an energy density or fluence of 15 J/cm^2, and one using 18 J/cm^2. All laser pulses were delivered through a single layer of a transparent, hydrogel-based wound dressing (*Vigilon*®, C.R. Bard, Inc., Murray Hill, NJ) which was applied directly over the telangiectasias to be treated. The number of laser pulses delivered to each treatment site ranged from 2 to 7 pulses. The vessels were treated with the major axis of the laser spot aligned along the length of the vessel until the entire vessel was traced out with minimal overlap. The telangiectasias treated ranged from 0.5 cm to 3.0 cm in length and were typically located at or below knee level.

Following laser treatment, an antibiotic salve (Polysporin®, Burroughs Wellcome, Research Triangle Park, NC) and a localized pressure bandage were applied to each treatment site for a period of hours. Color 35-mm slides were taken of each treatment site before and immediately after laser treatment, and on two scheduled follow-up visits at 6 weeks and 20 weeks (5 months) post-treatment.

After the final follow-up visit, the 35-mm color slides taken of each leg vein site at each follow-up visit were viewed by four observers in a blinded fashion. Each observer was asked to score the clearance of each site based on a 0 to 4 scale, with simultaneous projection. Clearance was defined as a lightening or fading of the vessel. The scores represented the percentage clearance observed as shown in Table 2.

The scores from the four observers were av-

TABLE 2. Leg Telangiectasia Clearance Evaluation Scores

Score	Clearance percentage
0	0–24
1	25–49
2	50–74
3	75–94
4	95–100

eraged to obtain one score for each treated site at both the 6-week and 5-month follow-up times. Observers also indicated for each site whether complications due to hyper- or hypopigmentation were present.

RESULTS

Fourteen of the 20 patients returned for evaluation at the 6-week follow-up visit, and 18 of 20 for the 5-month follow-up visit. Two patients, reflected in these totals, did not return for either follow-up visit, whereas an additional four missed only the 6-week visit. No retreatments with the PDL were administered at either follow-up visit.

As previously discussed, one African-American patient that did not meet initial inclusion criteria based on skin type was included in the study. For purposes of compiling and analyzing the data generated from the photography performed at the follow-up visits, the results obtained from this patient are held separate from the main body of patients. The telangiectiasias treated on this patient received clearance scores of zero for all three treated sites at both the 6-week and 5-month follow-up visits. Presence of hyperpigmentation was noted for all three treated sites at both follow-up visits.

With respect to the main body of patients, ($n = 13$ at 6-week follow-up, $n = 17$ at 5-month follow-up) the clearance scores assigned by the observers at 6 weeks and 5 months were distributed as in Tables 3 and 4, respectively.

COMPLICATIONS

Hyperpigmentation

Hyperpigmentation was the most commonly observed side effect of the long pulse dye laser treatments, being noted in 30.8% of the treatment sites at the 6-week follow-up visit for both treatment fluences. By the 5-month follow-up, however, hyperpigmentation was not noted in any of the treated sites. Actual distributions of the hyperpigmentation are noted in Table 5.

Hypopigmentation

Occurrences of hypopigmentation were noted by the observers at the 6-week follow-up visit in 15.4% of the treated sites, about half as frequently as hyperpigmentation. Again, however, by the 5-month follow-up visit no evidence of hypopigmentation remained in any of the sites. Actual distributions of the hypopigmentation are shown in Table 6.

DISCUSSION

The absorption coefficient for oxygenated blood at 585 nm is approximately 19 mm^{-1}. This means that in blood, 585 nm light will be reduced to 1/e or 37% of its intensity in 1/19 mm, or about 0.05 mm. Therefore in the case of a 0.5-mm-diameter vessel typical of leg telangiectasia, light at 585 nm will penetrate only about one-tenth of the way into the vessel. If the laser pulse duration is short compared with the thermal diffusion time constant for the vessel (approximately 200 msec in the case of a 500-μm-diameter vessel) the heating will be confined to a thin superficial layer on top of the vessel during the laser pulse. This is likely not to be sufficient to coagulate or thrombose the whole vessel.

The absorption of laser energy in blood vessels over the wavelength range 585–600 nm decreases dramatically with longer wavelengths. For example, at 600 nm the absorption coefficient of oxyhemoglobin is about one-fifth of that at 585 nm. Thus, at longer wavelengths the penetration depth will increase, and for vessels larger than 100 μm the heating will become more uniform over the whole vessel. Therefore, one possible way to improve the treatment for leg veins is to use wavelengths longer than 585 nm. However, one must bear in mind that to achieve comparable vessel injury, concomitant increases in fluence are required to compensate for the decreased absorption and increased volume of blood being heated. At comparable fluences the decrease in blood absorption will lead to decreased vessel effect for wavelengths longer than 585 nm despite the increase in penetration [4].

More uniform energy distribution in the vessels will also have the effect of lengthening the time interval over which the vessels will remain heated. For example, if a 0.5-mm-diameter vessel is heated uniformly, then it will cool at a rate

TABLE 3. Clearance Score Distribution at 6-Week Follow-Up

Treatment fluence	Clearance scores at 6-week follow-up, n = 13 patients (%) 0	1	2	3	4
15 J/cm^2 (n = 26 sites)	9/26 (34.6)	6/26 (23.1)	7/26 (26.9)	4/26 (15.4)	0/26 (0.0)
18 J/cm^2 (n = 13 sites)	5/13 (38.5)	2/13 (15.4)	4/13 (30.8)	2/13 (15.4)	0/13 (0.0)

TABLE 4. Clearance Score Distribution at 5-Month Follow-Up

Treatment fluence	Clearance scores at 5-month follow-up, n = 17 patients (%) 0	1	2	3	4
15 J/cm^2 (n = 34 sites)	7/34 (20.6)	5/34 (14.7)	4/34 (11.8)	11/34 (32.4)	7/34 (20.6)
18 J/cm^2 (n = 17 sites)	4/17 (23.5)	2/17 (11.8)	0/17 (0.0)	7/17 (41.2)	4/17 (23.5)

TABLE 5. Occurrence of Hyperpigmentation

Treatment fluence	Occurrence of hyperpigmentation (%) At 6-week follow-up	At 5-month follow-up
15 J/cm^2	8/26 (30.8)	0/34 (0)
18 J/cm^2	4/13 (30.8)	0/17 (0)

TABLE 6. Occurrence of Hypopigmentation

Treatment fluence	Occurrence of hypopigmentation (%) At 6-week follow-up	At 5-month follow-up
15 J/cm^2	4/26 (15.4)	0/34 (0)
18 J/cm^2	2/13 (15.4)	0/17 (0)

given by its thermal diffusion time constant which, for this size vessel, is on the order of 200 msec. The peak temperature needed to achieve vessel injury in this case is likely to be lower than that required for a smaller vessel which cools more quickly.

In order to treat leg veins at longer wavelengths and higher fluences, one needs to be cognizant of the fact that unlike blood absorption, which decreases quickly with increasing wavelength, melanin absorption does not. Over the wavelength interval of 585–600 nm, melanin absorption remains essentially constant. At higher fluences epidermal effects can be expected to become more significant. Additionally, as blood absorption decreases in the dermis, back scatter of the laser light from the dermis will increase. Thus, if higher fluences are to be tolerated by the epidermis where the absorption is dominated by melanin, one will need to mitigate the increased energy absorption by the epidermis.

Epidermal melanin is concentrated mostly in the basal layer, which is typically about 20 μm in thickness. The thermal diffusion time constant for this layer is on the order of 0.4 msec. If the laser pulse can be made significantly longer than this, then one can expect some thermal diffusion to occur during the laser pulse. This will help in limiting the thermal injury to the epidermis.

Epidermal conductive cooling is normally limited to heat conduction down into the dermis. If a transparent hydrogel dressing is placed over the skin during treatment, then it will act as a heat sink allowing heat conduction away from the epidermis up into the dressing. This should further limit the peak temperatures reached in the epidermis if the laser pulse duration is substantially longer than the thermal diffusion time of the epidermis. This may also help to mitigate excessive epidermal injury. Superficial cutaneous cooling could further limit the thermal destruction of the epidermis.

The patients tolerated the treatment very well even when the highest fluence of 18 J/cm^2 was used. No anesthesia was needed with any of the patients, who for the most part reported only mild stinging during treatment. There were no incidences of permanent scarring. The only notable complications were transient hyper- or hypopigmentation which uniformly cleared by 5 months. It is interesting to note that the fluences used here were twice those generally considered safe for vascular lesion treatment at 585-nm and 450-μsec pulse duration.

It is also interesting to note that improvements in vessel clearance were seen at 5 months compared with those seen at 6 weeks, despite the fact that no additional treatments were administered. At 6 weeks the percentage of non-responding sites (score of zero) of all the sites treated with either fluence was 36% (14 of 39). By 5 months this decreased to 21% (11 of 51). At the same time the percentage of sites showing clearance scores

of 50% or greater (scores of 2, 3, or 4) increased from 44% (17 of 39) at 6 weeks to 65% (33 of 51). This is similar to the behavior seen in other vascular lesion responses to laser treatment, although it is likely that clearance would be slower in response to laser injury in the case of leg veins because the vessels are larger.

The clearance rate at 18 J/cm^2 seemed nominally better compared to 15 J/cm^2, but the difference would not bear statistical significance given the small sample size of treated sites. Nonetheless, the observation that better than 75% clearance (score of 3 or 4) of the telangiectasias was observed in 18/34 (52.9%) sites treated with 15 J/cm^2 and in 11/17 (64.7%) of sites treated with 18 J/cm^2 proves promising for the future of this technique.

Furthermore, these results are clearly superior to those seen previously with 585-nm and 450-μsec pulse duration. For this study only vessels greater than 0.6 mm in diameter were selected, as previous studies using 585-nm and 450-μsec pulses showed particularly poor response for these larger vessels. Had a more representative cross-section of vessels been treated by including a larger percentage of the more commonly encountered vessels with diameters 0.1 to 1.0 mm, the results would likely have been better.

Compared to sclerotherapy, which has been reported to produce a clinical response in over 90% of patients after one to four treatments [6], the clearance rate seen with the PDL is lower. However, it should be pointed out that the results reported here are those obtained after only one laser treatment. Additional treatment sessions may produce still better clearance. In addition the treatment may not be optimal in terms of wavelength and fluence. Still longer wavelengths and higher fluences may prove to be more effective, especially for leg veins larger than 1.0 mm in diameter. Further optimization of these parameters may lead to improved clearing. Other advantages of a laser treatment over sclerotherapy include the lack of complications such as telangiectatic matting and cutaneous necrosis that are sometimes encountered with sclerotherapy.

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